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Mr. Randy Matty, P.E.
Air Management Engineer
Wisconsin Department of Natural Resources
2984 Shawano Ave.
Green Bay, WI 54313-6727

August 15, 2014

RE: PS-11 Test Protocol for correlation of the SICK SP100 PM CEMS

Dear Mr. Matty:

Enclosed are two copies of Test Protocol No. 4960 for the PS-11 Certification Test Program, prepared by AIRTECH Environmental Services Inc. for the Manitowoc Public Utilities. Manitowoc Public Utilities is scheduling the installation of a SICK SP100 to meet the requirements of the EPA MATS regulations for Boiler 9. This protocol will be used to perform Performance Specification (PS)-11 particulate matter (PM) testing to establish a correlation curve for the PM continuous emissions monitoring system (PM CEMS) to be installed in Boiler B09.

If you have any questions regarding this protocol or need additional information please don't hesitate to contact me.

Sincerely,

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Environmental Engineer
Manitowoc Public Utilities
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Cc: Red Jones – MPU
Jerry Ahlswede – MPU
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Test Protocol for the PS-11 Certification Test Program

**To be conducted for
Manitowoc Public Utilities
At the Manitowoc Power Plant
Facility ID 436035930
Located at
701 Columbus Street
Manitowoc, Wisconsin 54220**

*Protocol No. 4960
August 13, 2014*

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Project Overview

General

Airtech Environmental Services Inc. has been contracted by Manitowoc Public Utilities (MPU) to perform an air emission test program at the Manitowoc Power Plant located in Manitowoc, Wisconsin (Facility ID 436035930). The specific objective of the test program is as follows:

- Perform Performance Specification (PS)-11 particulate matter (PM) testing to establish a correlation curve for the PM continuous emissions monitoring system (PM CEMS) installed to determine the concentration of PM at the exhaust of one (1), coal-fired boiler, designated as Boiler B09.

Testing will be performed to meet the requirements of MPU; the Wisconsin Department of Natural Resources (WDNR) air permit number 436035930-P22; the United States Environmental Protection Agency (U.S. EPA); and 40 CFR Parts 60 and 63, as applicable.

All testing will be performed by Airtech Environmental Services Inc. Coordinating the field portion of the test program will be:

| Thomas Reed | Brandon Check |
|---|--|
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Methodology

EPA Method 5 will be used to determine the concentration of PM at the test location. In EPA Method 5, a sample of the gas stream will be withdrawn isokinetically from the test location, and the PM in the sample gas will be collected in a heated, glass-lined probe and on a heated, quartz fiber filter. The probe and filter will be maintained at a temperature of 320°F +/-25°F, in accordance with 40 CFR Part 60.50Da. The weight of PM collected with the sample train, combined with the volume of dry gas withdrawn from the test location will then be used to calculate the PM concentration. A total of twenty (20) PM test runs will be performed.

Results for PM will be reported in units of milligrams per wet standard cubic meter (mg/wscm). Gravimetric analysis of the collected samples will be performed on-site. Airtech will provide all final test results before demobilizing from the job site.

In order to establish and maintain proper isokinetics, the volumetric gas flow rate will be determined during each test run using EPA Methods 1, 2, 3B, and 4.



PS-11 Correlation Test

The correlation test will consist of a total of twenty (20) test runs, at three (3) PM concentration levels, over a three (3) day period. These levels are defined as follows:

- Level 1 (Low): 0%-50% of the maximum PM concentration
- Level 2 (Mid): 25%-75% percent of the maximum PM concentration
- Level 3 (High): 50%-100% of the maximum PM concentration

The test program will consist of seven (7) test runs at low PM concentration (normal operations), seven (7) test runs at mid PM concentration, and six (6) test runs at high PM concentration.

The PM correlation data will be evaluated using the procedures in §12.3 of PS-11. The correlation data must contain a minimum of fifteen (15) data points. There is no maximum to the number of data points that can be used to develop the correlation curve. If more than fifteen (15) test runs are used as part of the correlation test, then up to five (5) test runs may be excluded from the calculations for determining the correlation curve without any explanation. However, if more than five (5) test runs are rejected, then an explicit reason must be stated. All test data, including rejected test runs, will be reported.

Gravimetric analysis of the collected samples will be performed on-site. Airtech will provide sufficient desiccators and balances to insure all samples can be processed in a timely manner. Final results (including blanks) will be provided before the laboratory technician leaves the site.

Each test run will be conducted for the duration as specified by PM concentration levels below:

- Level 1 (Low): ~120 minutes
- Level 2 (Mid): ~60 minutes
- Level 3 (High): ~60 minutes

Parameters

The following parameters will be determined at the boiler exhaust during each test run:

- carbon dioxide concentration
- oxygen concentration
- particulate matter concentration
- moisture concentration
- gas velocity
- gas temperature

Special Considerations

The following special considerations will be implemented during test program:

Main Test Program:

- All sample trains will be operated with probe and filter temperatures of 320°F +/- 15°F as allowed by 40 CFR Part 60.50Da.
- Two test crews running method 5 sampling trains.
- Duplicate trains will be used for all runs and only paired trains meeting the relative deviation (RD) requirements listed in the PM CEMS Knowledge Document will be used.

Sample Analysis:

- Final sample analysis for all 20 test runs to be performed on-site.
- Laboratory space will be made available for Airtech for oven, desiccators and balance.
- Sample analysis will include blanks and proof blanks analyzed on-site
- The alternative procedure in M5 section 8.1.3 will be used for filters and acetone rinse drying, by oven drying at 220°F for 2 to 3 hours, desiccating for a minimum of 2 hours and weighed for the first weight.
- Second weight to be constant must be +/- ≤0.3 mg
- Laboratory person will remain on-site until final weights are obtained and final QA reviewed results are provided.
- Particulate concentration will be reported in units of mg/wscm.
- Results will be provided in the field will be final and shall not change in the final report.

Unit De-Tuning

To achieve the three (3) distinct PM emission levels required by PS 11, MPU will attempt to “de-tune” the air pollution controls on the unit. While every reasonable effort will be made to ensure that the Unit stays within permissible limits, MPU is formally requesting immunity from enforcement action in the event that any PM CEMS and/or RM data collected during the certification test program exceeds the allowable limit.

Additional QA

The following additional testing requirements, beyond the method requirements, will be implemented during test program:

1. Maintain probe and filter temperature within $\pm 15^{\circ}\text{F}$ of the target temperature (320°F).
2. Measure filter temperature with a thermocouple in the gas stream on the back side of the filter frit.
3. Keep power to the heaters on until the very end of the sampling time.
4. Maintain isokinetic sampling at $\pm 5\%$ of 100%.
5. Use a calibrated Pitot tube coefficient, not the default 0.84.
6. Weigh samples to a constant weight of 0.3 mg instead of 0.5 mg.
7. Use glass probe liner and glass nozzle, no stainless steel shall be used.
8. Use Quartz glass filters, not borosilicate glass filters.
9. Use sampling rate of 1.0 cfm instead of 0.75 cfm.
10. Use glass bottles with Teflon lined caps for acetone rinse storage.
11. Use Teflon squeeze bottles for rinsing the probe.
12. Rinse probe and nozzle before each day's testing.
13. Collect a Proof Blank after each train's first run of the day. This is a rinse of all glassware in front of the filter after the sample is recovered.
14. Use consistent amount of acetone for each rinse. Recommend using 20 ml per foot of probe liner length.
15. Change the probe rinse brush and nozzle rinse brush after each test day.
16. Use a lint-free towel on the probe brush extension tube when pushing the brush down the liner.
17. Remove tags on the probe brush extension tube when they form.
18. Use new powder-free gloves when rinsing the probe.
19. Hang a tarp over the sample recovery area.
20. Cover all ports not being used and stuff a towel, rag, etc. in port being used.
21. Keep probe level and square at all times when in the stack.
22. Move the probe to the next traverse point at exactly the same time every time the probe is moved.
23. Put probe in stack no more than 5 minutes before starting a test run. See the MSI test coordinator for approximate start time.

ASTM D7036 - 04(2011)

All Airtech field personnel on-site for this test program will be compliant with ASTM D7036 - 04(2011) "Standard Practice for Competence of Air Emissions Testing Bodies" for all tests performed, as applicable.

Airtech actively participates in the Source Evaluation Society (SES) and Qualified Stack Test Individual (QSTI) program under the American Society for Testing and Materials (ASTM) Standard D7036 and has achieved interim accreditation through the Stack Testing Accreditation Council (STAC). The following table summarizes the experience level of key personnel that will be involved with this project:

| Personnel | Position | Years of Field Experience |
|--------------------------|-------------------------------------|---------------------------|
| Matt Libman, Q.S.T.I. | Field Test Leader | 7 |
| Brandon Check, Q.S.T.I. | Project Manager, Field Test Leader | 7 |
| Michael Hess, Q.S.T.I. | Field Test Leader, Field Technician | 5 |
| Timothy Giffin, Q.S.T.I. | Field Test Leader, Field Technician | 5 |

Proposed Test Schedule

Testing has been tentatively scheduled to occur the week of October~~??~~, 2014. Testing will take place in accordance with the following schedule of events:

| Day | Location | Activity | Test Method | No. of Runs |
|-----|------------|--|--------------------------|-------------------|
| 1 | Boiler B09 | Travel and set up Perform correlation testing at Normal PM Level | EPA 1, 2, 3B, 4 & MATS 5 | 2 (120 min. each) |
| 2 | Boiler B09 | Perform correlation testing at Normal PM Level | EPA 1, 2, 3B, 4 & MATS 5 | 5 (120 min. each) |
| 3 | Boiler B09 | Perform correlation testing at Mid PM Level | EPA 1, 2, 3B, 4 & MATS 5 | 7 (60 min. each) |
| 4 | Boiler B09 | Perform correlation testing at High PM Level | EPA 1, 2, 3B, 4 & MATS 5 | 6 (60 min. each) |
| 5 | | Complete gravimetric analysis Break down test equipment Demobilize from job site | | |

Test Procedures

Method Listing

The following test methods and performance specifications (PS) found in 40 CFR Parts 60 Appendices A and B, and 63 will be referenced for this test program:

| | |
|------------------------------|---|
| Method 1 | Sample and velocity traverses for stationary sources |
| Method 2 | Determination of stack gas velocity and volumetric flow rate (Type S pitot tube) |
| Method 3B | Determination of oxygen and carbon dioxide concentrations in emissions from stationary sources |
| Method 4 | Determination of moisture content in stack gases |
| Method 5 | Determination of particulate matter emissions from stationary sources |
| Method 19 | Determination of sulfur dioxide removal efficiency and particulate matter, sulfur dioxide, and nitrogen oxides emission rates |
| Performance Specification 6 | Specifications and test procedures for continuous emissions monitoring systems in stationary sources |
| Performance Specification 11 | Specifications and test procedures for particulate matter continuous emission monitoring systems at stationary sources |

Method Descriptions

Method 1

EPA Method 1 will be used to determine the suitability of each test location and to determine the traverse points used for the gas stratification and velocity traverses.

Boiler B09 is a round, horizontal duct with a diameter of 28.0 feet. Two (2) points in each of four (4) test ports will be traversed for each test run at each of the boilers. All test locations meet the minimum requirements of being located at least 2.0 diameters downstream and at least 0.5 diameters upstream from the nearest flow disturbances. A cross-section of the test locations, indicating the traverse points is shown in Figure 1 of the Appendix.

Method 2

EPA Method 2 will be used to determine the gas velocity through the test location using a type S pitot tube and an incline plane oil manometer. A diagram of the Method 2 sampling apparatus is shown in Figure 2 of the Appendix.

The manometer will be leveled and “zeroed” prior to each test run. The sample train will be leak checked before and after each run by pressurizing the positive side, or “high” side, of the pitot tube and creating a deflection greater than or equal to three inches (in.) of water (H₂O) on the manometer. The leak check will be considered valid if the manometer remains stable for 15 seconds. This procedure will be repeated on the negative side by generating a vacuum equal to at least three in. H₂O. The velocity head pressure and gas temperature will then be determined at each point specified by EPA Method 1. The static pressure of the test location will be measured using a water filled U-tube manometer. In addition, the barometric pressure will be measured and recorded.

Method 3B

The carbon dioxide and oxygen content of the stack gas was determined at the test location using EPA Method 3B. A gas sample was collected into a Tedlar bag from the back of the Method 5 sample train for the duration of each test run. Analysis was performed using an Orsat gas analyzer.

The analyzer was leak checked prior to analysis by raising the liquid levels in each pipette to a reference mark on the capillary tubes and then closing the pipette valves. The burette solution was raised to bring the meniscus onto the graduated portion of the burette and the manifold valve was closed. The leak check was considered valid if after four minutes, the pipette meniscus did not fall below the reference mark and the burette meniscus did not fall by more than 0.2 percent.

The carbon dioxide content and oxygen content were used to calculate the dry molecular weight of the gas stream. The molecular weight was then used, along with the moisture content determined by EPA Method 4, for the calculation of the volumetric flow rate. For these calculations, the balance of the gas stream was assumed to be nitrogen since the other gas stream components are insignificant for the purposes of calculating molecular weight.

Method 4

The moisture content at each test location will be determined using EPA Method 4. The moisture content will be used to calculate the molecular weight of the gas stream. A sample of the stack gas will be withdrawn from the source, the moisture condensed, and the quantity of collected moisture will be determined volumetrically and gravimetrically. A diagram of the EPA Method 4 sampling apparatus is shown in Figure 3 of the Appendix.

To condense the water vapor the gas sample will pass through a series of four condenser jars. The first two condenser jars will each contain 100 milliliters (ml) of water. The third condenser jar will be initially empty and the fourth will contain a known weight of silica gel to absorb any remaining water vapor. After the test run the amount of water gain in the condenser system will be measured volumetrically with a graduated cylinder. The silica gel weight gain will be determined gravimetrically. The volume of moisture collected will be compared to the volume of dry gas sampled to calculate the moisture content.

Method 5

EPA Method 5 will be used to determine the particulate matter concentration at the test location. In EPA Method 5, a sample of the gas stream will be withdrawn isokinetically from the test location, as applicable. Sampling will be maintained isokinetically at 100% \pm 5%. The particulate matter in the sample gas stream will be collected in a glass sample probe and on a quartz fiber filter. The weight of particulate matter collected with the sample train combined with the volume of dry gas withdrawn from the stack is used to calculate the PM concentration.

The sample probe used will consist of a heated glass liner and glass nozzle. Sample gas will pass through the nozzle and probe assembly and then through a heated quartz fiber filter. Both the probe and filter will be heated to a target temperature of 320°F \pm 25°F to prevent the condensation of water. After exiting the filter, the sample gas will pass through the condenser system described in Method 4. The dry gas exiting the gas condenser system will then pass through a sample pump and a dry gas meter to measure the gas volume. After leaving the dry gas meter, the sample stream will pass through an orifice, which is used to meter the flow rate through the sample train. The pressure drop across the orifice will be measured with an incline oil manometer.

Prior to the test run the filter will be weighed to the nearest 0.5 milligram and loaded into the filter holder. The probe will be thoroughly cleaned with 20 ml of acetone per foot of probe and the probe wash saved as a quality assurance check. The condenser system will be loaded as outlined in Method 4. After assembly, the sample train will be leak checked prior to the test run by capping the probe tip and pulling a vacuum greater than the highest vacuum expected during the test run. A leak check will be considered valid if the leak rate is below the lesser of 0.02 cubic feet per minute or four percent of the average sample rate.

The probe tip will be placed at the first of the sample points determined in Method 1. The velocity at the sample point will be determined using Method 2 by reading the velocity pressure from the oil manometer. Sample will be withdrawn from the source at a rate such that the velocity at the opening of the nozzle matches the velocity of the stack gas at the sample point (isokinetically). During the test run the train will be moved to each of the Method 1 sample points. The sample time at each point will be calculated based on the number of sample points and the run time. The gas velocity pressure, gas meter reading, gas meter inlet and outlet temperatures, gas meter orifice pressure and pump vacuum will be recorded for each sample point.

After the test run the train will be leak checked at the highest vacuum encountered during the test run. The probe liner and nozzle will be washed with 20 ml of acetone per foot of probe and the rinse saved. The quartz fiber filter will be removed from the filter holder, transferred to a Petri dish and sealed. The condenser contents will be recovered as outlined in Method 4 and discarded.

Analysis of the samples will be performed onsite. The probe rinse will be transferred to a tared beaker, evaporated, and then both the beaker and quartz filter will be oven-dried at

220°F for two to three hours, desiccated for two (2) hours, and weighed to a constant weight. The weight gain of the probe rinse and glass fiber filter yield the total weight of particulate sampled.

Description of Installation

Manitowoc Public Utilities (MPU) is an electric cogenerating facility located in the City of Manitowoc Wisconsin. This plant includes two atmospheric pressure, circulating fluidized bed (CFB) boilers, designated as Boilers 8 (B28) and 9 (B09). Boiler 8 was installed in 1990, and is permitted to fire coal, petroleum coke, paper pellets, biomass, rubber waste derived fuels, natural gas, or other alternative fuels as approved by the Department. The Foster Wheeler Fluidized Bed Boiler is rated at 200,000 lbs. of superheated steam per hour at 975 psig and 905 degrees F. It is equipped with an economizer and air preheater and exhausts through a baghouse.

Boiler 9 (B09) was installed in 2004, and is permitted to fire coal, petroleum coke, renewable biomass and natural gas (start-up and load stabilization.) The Kvaerner/Mesto Fluidized Bed Boiler is rated at 475,000 lbs. of superheated steam per hour at 1,500 psig and 1,000 degrees F. It is equipped with an air preheater and exhausts through a baghouse.

Boiler 9 (B09) has a 9-foot diameter exhaust. The diagram for the unit's ductwork is attached with the B09 method 1 in the appendix. The drawings include the testing platform and test port details.

Appendix

Figures

Sample Calculations

Sample Data Sheets

Calibration Sheets